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Article

Impact of Caffeine use on Adults' Sleep & Memory

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ABSTRACT

Caffeine is widely consumed globally, and its effects on sleep and memory have significant implications for public health, with variability in caffeine content across products making it challenging to assess its exact impact. This study aimed to determine the effects of caffeine on adults' sleep and memory, while also examining gender differences in these cognitive functions. A correlational research design was employed, focusing on adults aged 26-44 years who were addicted to caffeine, enrolled at Allied Hospital II from August 10, 2023, to July 20, 2024. Participants receiving other treatments were excluded, and data was collected using the Caffeine Consumption Questionnaire, Sleep Performance Questionnaire, and Cognitive Failure Questionnaire after obtaining approval from PDBS and informed consent. SPSS version 26 was used for analysis, revealing that caffeine use significantly influenced memory and sleep, with notable gender differences in sleep quality but no differences in cognitive failures or caffeine consumption. The study concluded that caffeine affects sleep and memory, highlighting gender variations in sleep quality, and recommended further research to explore these relationships and develop guidelines for caffeine intake.

KEYWORDS: *Adults, Sleep, Memory, Caffeine Use, Impact of Caffeine*

Introduction

Caffeine is found in various products, including coffee, tea, soft drinks, hot chocolate, confectionery like chocolate, and many over the counter medications such as cold remedies and pain relievers. The caffeine concentration varies between products, and the content within each product can fluctuate due to several factors. It is essential to note that caffeine content is highly variable due to plant growth, quality, and manufacturing and brewing techniques. Consequently, this variability presents challenges in assigning a consistent caffeine content value to each source (Brice & Smith, 2002).

People worldwide have consumed and enjoyed caffeine from natural sources for centuries, possibly dating back to the Paleolithic period. The widespread natural presence of caffeine in various plants has significantly contributed to the enduring popularity of caffeine containing products, especially beverages. Over 60 plant species around the world have been identified as containing caffeine. In South America, beverages made from native plants like guarana, yoco, and mate have ancient origins. Similarly, North American natives utilized the caffeine containing cassina (Barone & Roberts, 1984).

Caffeine is easily accessible from various food, beverage, and drug sources. In low to moderate doses (e.g., approximately 0.5–4 mg per kg of body mass, equivalent to about 37.5–300 mg for a 75 kg individual), it typically does not cause negative side effects. Consequently, caffeine is commonly used to counteract performance impairments caused by sleep loss. However, its effectiveness can depend on several factors, including the dose consumed, timing of administration, nature of the performance task, individual expectations, and the extent of sleep loss. Therefore, understanding the efficacy of caffeine intake, including appropriate doses and timing, is important to mitigate the adverse effects of acute sleep loss (Irwin et al., 2020).

Insufficient sleep is a growing health concern, with the CDC (Centers for Disease Control and Prevention) noting over a third of American adults lack adequate sleep. Caffeine delays sleep onset, reduces sleep efficiency, and worsens perceived sleep quality, while abstaining from caffeine improves it. As an adenosine receptor antagonist, caffeine inhibits sleep-inducing effects, leading sleep hygiene guidelines to recommend avoiding it for better sleep. People usually consume caffeine in the morning rather than before sleep (Hu et al., 2020).

This pattern is common among adults, while adolescents (13–17 years) consume caffeine more evenly throughout the day. It's unclear if morning caffeine affects the evening. Adenosine promotes sleep, and caffeine inhibits it, but 50% of caffeine is eliminated 5 to 7 hours after consumption. Although caffeine's half-life varies, its effects usually don't last all day. Caffeine is often used to combat sleepiness from sleep deprivation or jet lag, especially in middle-aged adults. Age affects sleep, caffeine intake, and their relationship. Research shows sleep quality declines and caffeine consumption increases with age, peaking among adults aged 50–64 years (Hu et al., 2020).

Human memory is one of the most fascinating subjects in psychology. Memory refers to the mental processes of encoding, retaining, and retrieving information. One of the most intriguing and challenging questions in contemporary memory research is how to improve human memory performance. Many researchers have identified several factors that enhance memory retention, including psychoactive substances like caffeine (Sarno & Sarno, 2022).

Memory involves encoding, storing, and retrieving information, divided into short-term, long-term, and working memory. Short-term memory holds information briefly. Jonides (2008) identified three steps for storing short-term memory: encoding (converting perceived information), maintenance (keeping memory available), and retrieval (bringing memory to consciousness). Caffeine is widely used for its cognitive and mood-enhancing benefits, impacting various aspects of human performance, particularly cognition. It's important to consider how caffeine affects and integrates into short-term memory (Sarno & Sarno, 2022).

Research shows caffeine is widely used, even among adolescents, for benefits in physical performance, alertness, and countering sleep deprivation. Olsen (2013) found college students use caffeine to stay awake, achieve high grades, concentrate, and enhance social interactions. Caffeine improves information processing, attention, and some memory types. Van-Duinen et al. (2005) found caffeine enhances performance in single, dual, and prolonged tasks. Baddeley (2006) noted caffeine helps with working memory tasks but may hinder those heavily reliant on it. Caffeine mainly improves reaction times, especially in low alertness conditions (Sarno & Sarno, 2022).

Caffeine is widely consumed for its alertness-boosting effects, yet it can negatively impact sleep and memory, essential functions for adults' daily well-being. Despite known differences in caffeine metabolism, limited research has explored gender-specific effects on sleep and memory. This study examines the relationship between caffeine use, sleep, and memory in adults and investigates gender differences in these effects. Findings aim to support the development of guidelines for caffeine intake that address potential gender-specific impacts on cognitive health.

Hypothesis

- There is likely to be a positive correlation between caffeine use on adults' sleep and memory.
- The caffeine use is likely to be a predictor on adults sleep and memory.
- To check the gender difference on adults sleep and memory.

Method

Research Design

The research followed a co-relational research design to study the relationship and its impact between caffeine use, sleep and memory on adults.

Sample

A Purposive sampling technique was used with the sample of 100 adults aged between 26-44 years was drawn from adults who have caffeine consumption from Allied Hospital II Faisalabad Pakistan. The sample size was calculated with a G power analysis with 0.05 alpha level, 0.20, beta value and r= 0.02. The study will use correlation and regression analyses to assess the associations between caffeine intakes, sleep quality, and memory performance.

Inclusion Criteria

The study included adults aged 26-44 years who were regular caffeine users during the study period. Participants had to provide informed consent and be willing to complete the necessary questionnaires, including the Caffeine Consumption Questionnaire, Sleep Performance Questionnaire, and Cognitive Failure Questionnaire. Additionally, individuals who did not have any other form of treatment affecting sleep or cognitive function were eligible for inclusion in the study.

Exclusion Criteria

Individuals outside the age range of 26-44 years were excluded from the study. Participants who were receiving treatment for sleep disorders, cognitive impairments, or any other medical conditions that could influence the study's outcomes were also excluded. Additionally, pregnant or nursing women were not included in the study, nor were individuals who did not provide informed consent or fail to complete the required questionnaires.

Instruments

Caffeine Consumption Questionnaire

Cognitive Failure Questionnaire

Pittsburg Sleep Quality

Caffeine Consumption Questionnaire: This scale, introduced by John Preston in 2015. CCQ measures self-reported weekly caffeine intake and details the amount and type of caffeinated products consumed, including coffee, soft drinks, tea, cocoa, chocolate, and over the counter drugs. The questionnaire consists of 20 items and is designed to be more accessible and engaging by using pictures of commonly consumed products, visual aids for serving sizes, and images of widely commercialized items (Irons et al., 2016).

Cognitive Failure Questionnaire: Introduced by Broadbent, Cooper, FitzGerald, and Parkes in 1982, the CFQ is used in ergonomics research to measure behavioral issues related to attentiveness and memory in daily life. CFQ scores have been linked to constructs like accident proneness and outcomes such as human error and psychological strain. The test-retest reliability of the total CFQ score has been found to be 0.717 (Bridger et al., 2013).

Pittsburg Sleep Quality: PSQI is a 19-item, self-rated questionnaire designed to assess sleep quality and disturbances over the past month in clinical populations. The 19 items are categorized into 7 components: sleep duration, sleep disturbance, sleep latency, daytime dysfunction due to sleepiness, sleep efficiency, overall sleep quality, and use of sleep medication. Each component is scored from 0 to 3, with 3 indicating the greatest dysfunction. The component scores are summed to produce a total score ranging from 0 to 21, with higher scores indicating worse sleep quality. A global PSQI score greater than 5 distinguishes between good and poor sleepers, with a sensitivity of 89.6% and a specificity of 86.5% (Zhong et al., 2015).

Procedure

The study began by selecting 100 adults aged 26-44 years who were regular caffeine users from Allied Hospital II in Faisalabad, Pakistan, using a purposive sampling technique. After obtaining informed consent, participants completed three questionnaires: the Caffeine Consumption Questionnaire (CCQ), the Cognitive Failure Questionnaire (CFQ), and the Pittsburgh Sleep Quality Index (PSQI). The CCQ measured participants' weekly caffeine intake, the CFQ assessed cognitive failures related to memory and attentiveness, and the PSQI evaluated sleep quality and disturbances. Data was then analyzed using correlation and regression analyses in SPSS version 26 to explore the relationships between caffeine intake, sleep, and memory, with a focus on gender differences.

Ethical Consideration

The research were prioritize participant confidentiality, informed consent, and voluntary participation. It was also ensure that the study does not cause harm or discomfort to the participants and that the data collected is handled with utmost care and privacy.

Results

Table 1

Demographic of the participants of study. (N=100)

Demographics		Frequency	Percentage
Age	20 – 30	26	21.8
	31 – 40	41	34.5
	41 – 50	33	27.7
Gender	Male	50	42.0
	Female	50	42.0
Qualification	BS/MA	33	27.7
	MS/MPhil	41	34.5
	PhD	26	21.8
Occupation	Employed	52	43.7
	Unemployed	48	40.3
Socio-economic	Middle Class	71	59.7
Status	High Class	29	24.4
Living Situation	Joined	45	37.8
	Nuclear	55	46.2

Table 2

Minimum, Maximum, Mean and Standard Deviation of Scale Responses. (N=100)

Scale	Min	Max	Mean	SD	**α**
CCQ	20.00	32.00	25.56	2.74	.10
CFQ	7.00	81.00	52.38	17.47	.94
PSQS	33.00	74.00	52.25	9.13	.83

The descriptive statistics for the scale responses are presented in Table 2. For the Caffeine Consumption Questionnaire (CCQ), the scores ranged from a minimum of 20.00 to a maximum of 32.00, with a mean score of 25.56 and a standard deviation (SD) of 2.74. The reliability of this scale, as indicated by Cronbach's alpha (α), was quite low at .10, suggesting limited internal consistency. The Cognitive Failure Questionnaire (CFQ) had scores ranging from 7.00 to 81.00, with a mean score of 52.38 and a higher standard deviation of 17.47, indicating greater variability in responses. The reliability coefficient (α) for this scale was .94, indicating excellent internal consistency. For the Pittsburg Sleep Quality Scale (PSQS), the scores ranged from 33.00 to 74.00, with a mean of 52.25 and an SD of 9.13. The Cronbach's alpha for this scale was .83, reflecting good internal consistency.

Table 3

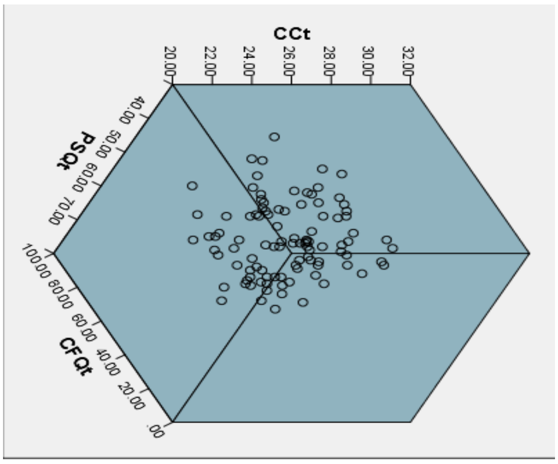
Relationship between Caffeine Consumption, Sleep and Memory among adults. (N=100)

Variables	CCQt	CFQt	PSQt
CCQt	1	.462**	.456**
CFQt	1	1	.279**
PSQt	1	1	1

Table 3 shows the correlation coefficients between Caffeine Consumption Questionnaire (CCQt), Cognitive Failure Questionnaire (CFQt), and Pittsburg Sleep Quality Scale (PSQt) among 100 adults. A moderate positive correlation exists between CCQt and CFQt ($r = .462$, $p < .01$), indicating that higher cognitive control is associated with greater cognitive flexibility. Similarly, CCQt is positively correlated with PSQt ($r = .456$, $p < .01$), suggesting that higher cognitive control is related to higher perceived stress. There is a smaller but significant positive correlation between CFQt and PSQt ($r = .279$, $p < .01$), indicating that increased cognitive flexibility is associated with higher perceived stress. All correlations are statistically significant at the $p < .01$ level, highlighting meaningful relationships between these variables.

Figure 1

Three-D Scatter Plot Showing the Relationship between Caffeine Consumption, Sleep and Memory among adults. (N=100)



The image depicts a three-dimensional scatter plot visualizing the relationships between three variables: Caffeine Consumption (CCt), Cognitive Failure (CFQt), and Pittsburg Sleep Quality (PSQt). Each axis represents one of these variables, with corresponding values labeled along the edges. The CCt axis ranges from 20 to 32. The CFQt axis ranges from 0 to 100. The PSQt axis ranges from 0 to 40. Data points, represented by circles, are plotted within this three-dimensional space, showing the distribution of the participants' scores across these variables. The plot suggests a clustered distribution around the center, indicating a concentration of similar scores among the participants. The visual also shows some spread, particularly along the CFQt axis, which aligns with the previous report of variability in cognitive flexibility scores.

Table 4

Independent Sample T-Test for Gender Differences among Caffeine Consumption, Sleep and Memory among adults. (N=100)

Variables	**Male** *(N = 50)*		**Female** *(N =50)*			***95% of CI***		
	M	***SD***	***M***	***SD***	***t***	***LL***	***UL***	***Cohen's d***
CCQt	25.00	2.49	26.12	2.88	-2.08	-2.19	-.05	.42
CFQt	52.20	16.69	52.56	18.38	-.10	-7.33	6.61	.02
PSQt	47.42	5.59	57.08	9.46	-6.21	-12.75	-6.57	1.24

Table 4 shows the results of an independent sample t-test comparing gender differences in Caffeine Consumption (CCQt), Cognitive Failure Questionnaire (CFQt), and Pittsburg Sleep Quality (PSQt) among 100 adults, split evenly between male and female participants. Males had a mean CCQt score of 25.00 (SD = 2.49) while females scored 26.12 (SD = 2.88), with a statistically significant difference ($t = -2.08$, $p < .05$) and a small to medium effect size (Cohen's d = .42). In CFQt scores, males averaged 52.20 (SD = 16.69) and females 52.56 (SD = 18.38), showing no significant difference ($t = -0.10$, $p > .05$) and a negligible effect size (Cohen's d = .02). However, PSQt scores revealed a significant gender difference, with males scoring 47.42 (SD = 5.59) and females 57.08 (SD = 9.46) ($t = -6.21$, $p < .01$), indicating a large effect size (Cohen's d = 1.24). This suggests that females reported significantly higher levels of perceived stress compared to males.

Table 5

Hierarchical Regression Analysis for Caffeine Consumption, Sleep and Memory, based Caffeine Consumption is Predicting in Sleep and Memory. (N=100)

Model	B	SEB	T	Sig	R^2	ΔR^2	F
Constant	17.02	1.36	12.48	.000	-	-	-
Caffeine Consumption	2.95	.57	5.16	.000	-	-	-
Cognitive Failure	.06	.01	4.19	.000	-	-	-

Sleep	.12	.12	4.10	.000	.33	.32	23.99

Table 5 outlines a hierarchical regression analysis that explores how caffeine consumption predicts sleep and memory among 100 adults. The analysis found that caffeine consumption significantly predicts the outcome variable, with a coefficient (B) of 2.95 and a standard error (SEB) of .57, yielding a t-value of 5.16 ($p < .001$). This indicates that higher caffeine consumption is associated with increases in the outcome variable. Additionally, cognitive failure and sleep were also significant predictors, with coefficients of .06 (SEB = .01, $t = 4.19$, $p < .001$) and .12 (SEB = .12, $t = 4.10$, $p < .001$), respectively, suggesting positive associations with the outcome variable. The model accounted for 33% of the variance ($R^2 = .33$), with an additional 32% explained by these predictors ($\Delta R^2 = .32$). The overall model was significant ($F = 23.99$, $p < .001$), highlighting the substantial role of caffeine consumption, cognitive failure, and sleep in predicting sleep and memory outcomes.

Discussion

The present research results indicate that caffeine consumption has relationship on memory and sleep in the present sample of adults. The results of the study supported the hypothesis that caffeine use has significant relationship with memory and sleep.

This study supports the first hypothesis regarding the relationship between caffeine use and sleep in adults. While caffeine is commonly thought to interfere with good sleep, we did not observe this association in our analysis of this national dataset. There are two potential explanations for this finding. First, individuals may have developed a tolerance to their regular caffeine intake, resulting in habitual use that does not significantly affect their sleep duration. Another possible explanation is that the timing of caffeine use could also influence its impact on sleep. As noted earlier, adults typically consume coffee in the morning, which may minimize its effect on nighttime sleep. Furthermore, this study investigated the reverse relationship. Despite extensive research on how caffeine affects sleep, there is relatively less literature on how sleep influences caffeine intake. We discovered that insufficient sleep was linked to increased caffeine use in the future, consistent with prior studies. Notably, this pattern was observed predominantly among middle-aged individuals, rather than the elderly (Irwin et al., 2020).

The findings of this study suggest that lifetime coffee use in women may affect cognitive processes differently depending on the type of cognitive function being measured. Most of the cognitive tests that showed positive associations with coffee intake included a verbal component. While these cognitive function tests were interconnected, they shared less than 30% of their variance. Correlations among the tests, excluding those between subtests, ranged from 0.11 to 0.54. Furthermore, the varying effects of coffee on different cognitive tests may be influenced by differences in the psychometric properties of these tests (Johnson-Kozlow et al., 2002).

This study supports the second hypothesis regarding the relationship between caffeine use and memory. Higher habitual caffeine intake was associated with faster simple response speed and enhanced long-term memory. However, habitual caffeine use did not show significant associations with short-term memory performance, planning capacity, information processing, or attention. The study found no age-related differences in sensitivity to habitual caffeine use on cognitive test performance (Hameleers et al., 2000).

The improvement in long-term memory performance linked to higher daily caffeine use suggests that habitual caffeine intake may enhance storage or retrieval processes in long-term memory. The study also indicated no acute effects of caffeine intake on working memory, short-term memory, or long-term memory across different task paradigms. However, participants with moderate to high habitual caffeine intake (mean of 710 mg/week) demonstrated better delayed recall performance, recalling more words compared to those with low habitual caffeine intake (mean of 178 mg/week). Overall, the study highlighted a positive relationship between habitual caffeine consumption and memory in a large population sample (Hameleers et al., 2000).

Implications

The study's findings suggest that caffeine use significantly affects both sleep and memory in adults, with gender differences observed in sleep quality. These results highlight the need for tailored public health guidelines regarding caffeine consumption, especially considering its potential impact on cognitive functions and sleep patterns. Healthcare providers may also need to consider caffeine intake when assessing patients for sleep disturbances or memory issues. Overall, the study emphasizes the importance of understanding the broader effects of caffeine, prompting further research to refine recommendations and inform healthier caffeine consumption habits.

Limitations

One limitation of this study is its reliance on self-reported data from questionnaires, which may be subject to biases such as recall bias or social desirability bias, potentially affecting the accuracy of the responses regarding caffeine consumption, sleep quality, and cognitive performance. Additionally, the study only included adults within a specific age range (26-44 years) and did not consider individuals outside this group, limiting the generalizability of the findings to a broader population. The exclusion of participants receiving other forms of treatment may also have introduced selection bias, as the impact of caffeine on individuals with pre-existing conditions or those taking medications was not assessed. Lastly, the cross-sectional nature of the study does not allow for the determination of causality between caffeine use, sleep quality, and memory, as it only identifies relationships rather than the directionality of effects.

Recommendations

Future research should explore a more diverse sample population, including a broader age range and individuals with varying health conditions, to better understand the generalizability of the findings. Longitudinal studies are recommended to examine the causal effects of caffeine on sleep and memory over time, as well as to track any long-term cognitive consequences of regular caffeine use. Additionally, further investigation into the gender differences observed in sleep quality could provide insights into whether specific biological or behavioral factors contribute to these disparities. Based on the findings, it is recommended that guidelines for caffeine consumption be developed, considering the potential impact on sleep and memory. Public health campaigns could promote awareness of the effects of excessive caffeine intake, emphasizing moderation and its potential cognitive consequences, particularly for individuals in high-risk groups, such as those with existing sleep disorders or cognitive impairments.

Conclusion

Caffeine use is significantly related to sleep and memory in adults. Gender differences in sleep quality highlight the need for tailored guidelines for caffeine intake. While habitual caffeine use may not severely impact sleep duration, its influence on long-term memory is noteworthy. The study suggests that timing and habituation to caffeine play crucial roles in its effects on sleep.

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